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Sex differences in educational attainment

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ABSTRACT

At the end of the 90s, Lynn knew that men have higher abilities and SAT scores. However, why then did females have higher grades in college? Analysing national databases and relevant literature, he concluded that the reason is in higher work ethics of females.

Lynn has analysed science achievement in large international studies. Males were better than females, especially 17–18 year olds, which corresponds to the higher abilities of males. However, the male advantage decreased over time and females performed as well as males by about 2008.

The next object of interest for Lynn was the variance in the test results for males and females. Seven international tests revealed that on average the variance for males was 12% larger than that for females. This is one explanation for the fact that there are more men in science than women.

Several lines of future research emerge from Lynn's studies. The decrease in the male advantage in science tests leads to the hypothesis that there should be different Flynn effects for boys and girls. While the causes of sex differences may be different at the individual and country level, multilevel analysis is a useful tool of further research.

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1. Introduction

In the last 20 years, Lynn and his followers have shown that males have higher intelligence than females (see paper by Irwing in this issue). For example, in Progressive Matrices, the male advantage is five IQ points (Lynn & Irwing, 2008, p. 233). The difference in intelligence appears after the age of 15 years, because girls develop faster and this enables girls to be as good as boys until the age of 15 years. The main reason for higher intelligence in males is seen in their greater brain size (Lynn, 1994, 1999; Lynn, Allik, & Must, 2000) and in some environmental factors that may be different for males and females.

Educational attainment is strongly related to intelligence. Sipe and Curlette (1996) have found in their meta-synthesis of educational research that on the individual level the effect of intelligence on educational attainment was .6 ($r = .5$). The effects of other variables (motivation, SES, teacher education, etc.) were smaller. The educational attainment of a person and his/her intelligence are interdependent: learning fosters intelligence and intelligence is an important factor of success in learning.

The relationship between international test results and the National IQ is even stronger at the country level. Lynn and Mikk (2007), Lynn, Meisenberg, Mikk, and Williams (2007) have found

correlations of .83–.92 between TIMSS and PISA test results and the National IQ. Rindermann (2007) has conducted a factor analysis of international test results and the National IQ and found that as indicators of the general cognitive ability of nations, international test results are as good as the National IQ tests.

Considering the relationship between IQ and educational attainment on the one hand, and sex differences in intelligence on the other, it is logical to conclude that there should be sex differences in educational attainment as well. We will reflect on Lynn's contribution to the studies of sex differences in educational attainment at the individual and national levels. Lynn has also contributed to studies of sex differences in the variance of educational achievement that will be presented together with some research developments.

2. Sex differences at the individual level

Richard Lynn became interested in sex differences in educational attainment in the late 90s. At this time, it was known that males are better at spatial abilities and science and it was accepted that males are better at maths. The results from analysing verbal abilities have given mixed results; most of the studies have indicated female superiority; however, in some studies males achieved better results in verbal tests as well.

The starting point for the studies was the contradiction between the higher scores by males in the Scholastic Aptitude Test (SAT) and American College Test (ACT) on the one hand, and the higher grades for females in college on the other. Mau and Lynn

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(2000,2001) and Lynn and Mau (2001) analysed the American National Educational Longitudinal Study (NELS) results for 20,612 tenth and twelfth grade students, SAT results for 3930 students and ACT results for 3553 students. In NELS, males obtained significantly higher mean scores in maths and science and females obtained significantly higher mean scores in reading and amount of homework. Males had higher scores in ACT and SAT including the verbal part of SAT, but females obtained a significantly higher Grade Point Average.

The higher results for males in most of the tests can be explained by their higher abilities. However, why did females have higher grades although their abilities were lower? Lynn and Mau explain this finding via the stronger work ethic of females that has been found in several studies. The existence of a stronger work ethic in females was also found in these studies in terms of the larger amount of homework done by females. Mau and Lynn (1999) have related the amount of homework to motivation in different groups of students. There may be male–female differences in other correlates of educational achievement as well, and this may explain the differences in the educational achievement of boys and girls. For example, female teachers may pay more positive attention to girls and this may foster the achievement of girls in comparison with boys. Mau and Lynn (2000, p. 123) have hypothesised that greater amount of homework completed by females may be related to greater levels of socialisation (lower rates of aggression, conduct disorders, etc.).

3. Sex differences at the country level

Some years ago, Lynn and Mikk (2008) conducted a comparative analysis of nine international studies by the International Association for the Evaluation of Educational Achievement and the Organisation for Economic Co-operation and Development from 1970 to 2006. The studies were carried out in up to 57 countries with representative samples of students consisting of several hundred thousand students in the largest studies. The tasks for measuring educational attainment were carefully composed and translated into the languages of the participating countries.

The findings of the analysis are summarised in Table 1. The difference in the attainment of males and females is expressed in the standard deviation units, which are calculated by dividing the difference in score points by the pooled standard deviation of the scores for males and females.

It can clearly be seen in the table that males outperformed females significantly in most of the studies. The largest difference is for 17–18 year olds and the smallest for 9–10 year olds.

Lynn and Mikk (2008) explain these findings by the differences in the abilities of boys and girls. The development of boys catches up with the development of girls by the age of 15 years and after this age the higher abilities of boys may cause their higher educational attainment. Before that age, there is no sex difference in abilities. Why then were 9–10 year old boys better than girls? Lynn and Mikk (2008, p. 120) say that this difference is because boys are more interested in science than girls.

Science can be divided into three kinds in the tests: physical systems, earth and space systems and living systems. The superiority of boys was the largest in the physical systems, but boys and girls had an almost equal level of knowledge in living systems. This finding may be related to the different interests of boys and girls.

In Table 1, we see the decrease of sex differences in science attainment year by year. In 1970, the difference was .46 for 13–15 year olds and only $-.07$ in 2006. The decrease is regular and a regression analysis revealed a correlation of .94 between the size of the effect and the year (Fig. 1). In Fig. 1 we can see the equality of male and female test results in 2006; afterwards females are

predicted to achieve higher results in science tests. An analogous regression analysis for 9–10 year olds revealed a coefficient of multiple correlations of .90 and the equality of results for boys and girls in 2008.

Lynn and Mikk (2008, p. 119) explain the diminution of the boys' advantage in science in two ways: "First, the boys and girls may be becoming more similar in ability and/or interests. Second, the content of the problems in the tests may have changed". In PISA field trial, the items were analysed on different aspects including gender-by-item analysis and some items were removed from the main study (PISA, 2006. Technical Report at: <http://www.oecd.org/dataoecd/0/47/42025182.pdf>, p. 41). This may have diminished the gender difference in science test results.

Let us move onto sex differences in reading, which also have been the object of studies for a very long time. Hyde and Linn (1988) found in their meta-analysis that girls had an advantage of .23*d* in studies prior to 1973, while in studies after 1973 it had dropped to .10*d*. The meta-analysis of sex differences in reading achievement by Lietz (2006) revealed that girls in secondary school performed .19 standard deviation units above boys. Most of the studies revealed superiority among females in different tests on reading; however, in some studies men obtained higher results than women. The analyses were made according to countries, and first of all, data from the USA were used.

Lynn and Mikk (2009) analysed the gender effect in reading in the three PISA and two PIRLS studies. PISA studies were carried out by OECD and most of the participating countries were also from OECD. The number of PISA countries has increased in the years 2000–2006 from 27 to 57 including non-OECD countries. There participated more than 250,000 students in the years 2000 and 2003 and more than 400,000 students in 2006. Nationally representative samples were tested in every country. The PIRLS studies have been carried out by IEA – International Association for the Evaluation of Educational Achievement. In the PIRLS studies countries from four continents (Europe, Asia, Africa, and America) were participating, however, European countries were prevailing. Representative samples of four–five thousand students were tested in every country. Summative gender effect sizes in reading in the studies are shown in Table 2.

In all five international studies, females significantly outperformed males in reading. The difference was .23 for 10 year olds and .42 for 15 year olds (Table 2). The difference is larger than found in earlier studies.

The female advantage in reading was larger than the male advantage in science if we consider the three PISA tests (Tables 1 and 2). In science, the superiority of boys was diminishing, but we do not have enough data to speak about the time trends for the superiority in reading among females because the time trend was statistically non-significant.

Table 1
Sex differences in science.

Study	Year	No. of countries	Difference in attainment (M–F)		
			9–10 year olds	13–15 year olds	17–18 year olds
IEA	1970	19	.23	.46	.69
IEA	1983	17	.23	.34	.31
IEA	1991	8	.16	.26	
TIMSS	1995	21/36*	.10	.19	
TIMSS	1999	38		.18	
PISA	2000	27		$-.00$	
TIMSS	2003	24/46*	$-.01$.08	
PISA	2003	41		.04	
PISA	2006	57		$-.07$	

Note: The first number of countries is for 9–10 year old students and the second number of countries is for 13–15 year olds.

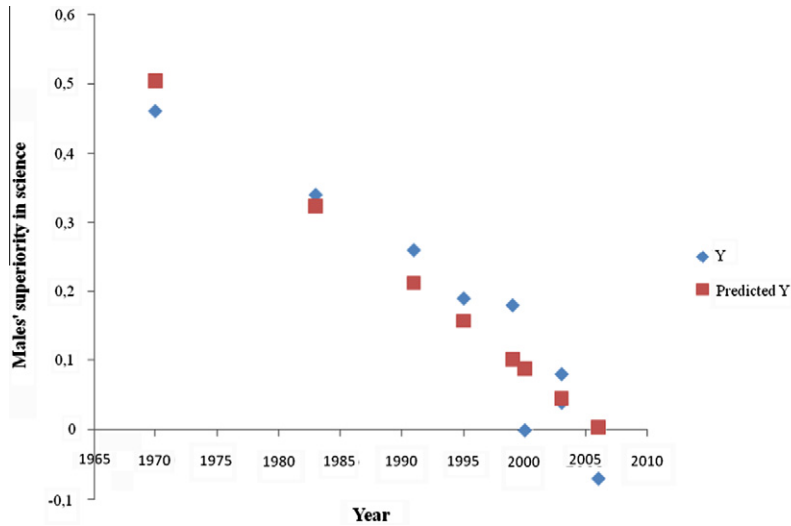


Fig. 1. The decline of the superiority in science for 13–15 year old males.

Table 2
Sex differences in reading achievement.

Study	Year	No. of countries	Difference in attainment (F–M)	
			10 years old	15 years old
PISA	2000	27		.49
PISA	2003	40		.36
PISA	2006	57		.41
PIRLS	2001	35	.25	
PIRLS	2006	40	.21	

Table 3
The ratio of males' variance to females' variance in science.

Study	Year	Subject	Variance ratio M/F	
			10 years old	13–15 years old
TIMSS	1995	Science	1.12	1.10
TIMSS	1999	Science		1.14
PIRLS	2001	Reading	1.08	
TIMSS	2003	Science	1.10	1.10
PISA	2003	Science		1.15
PISA	2003	Reading		1.20
PIRLS	2006	Reading	1.08	

The higher scores that females received in reading tests have been explained by their higher verbal abilities. Lynn and Mikk (2009) have looked for additional explanations using PISA 2006 data. They found that boys more often had DVR or VCR players that took time away from reading. Girls had more classical literature and poetry in their homes and more girls were from homes without a computer. Girls also had more regular lessons in language and they were confident that they are doing well in language.

4. Variance in the results of tests of males and females

The President of Harvard, Lawrence Summers, declared in 2005 that there are more men in science than women, not because of less average innate aptitudes of women but because of a larger dispersion of scores among men. This provoked a storm of protest to such an extent that he resigned his post. In 2007, Ceci and Williams edited the book “Why aren’t more Women in Science?” in which they concluded that on average females are as good as males in science and maths.

Above we saw Lynn’s studies about the advantage of males in international science studies that correlate with males’ higher abilities in science. However, Lynn has proposed another explanation for the multiplicity of men in science. The variance in males’ test results is higher than in females’ test results, and therefore, there are relatively more men in both ends of the distribution.

Lynn and Mikk (2008, 2009) have calculated the average ratios of males’ variance to females’ variance relying on data from the TIMSS, PIRLS and PISA studies. We can see in Table 3 that males’ variance in test results is 1.12 times larger than the variance in females’ test results. The variance ratio is larger for 13–15 year olds, which means that boys and girls are more different at 13–15 years than they are at 10 years of age.

The authors explained the greater variability in males’ test results by the greater variability in their abilities. Convincing data presented by many authors support the position that general intelligence has higher variability in males than in females (Ang, Rodgers, & Wänström, 2010; Deary, Irving, Der, & Bates, 2007; Deary, Whalley, & Starr, 2009; Johnson, Carothers, & Deary, 2008). Sex differences in variance of intelligence emerge before preschool (Arden & Plomin, 2006) and so they are not determined by educational influences but they may cause differences in variance of educational attainment. The greater interest in science among males and their higher competitiveness may lead to excellent attainment test results for some of them. Lynn and Mikk (2009, p. 12) hypothesise that “women have greater responsibility in bringing up the next generation and the fulfilment of this important task may be in danger in the case of a big variability which sometimes is a disadvantage in life”.

The larger variability in male test results explains why there are more men among the top achievers as well as bottom achievers in schools. Females do not vary so much and they prevail in the middle of the distribution of achievement and abilities test results.

5. Further developments in the research

The causes for sex differences in educational attainment have been explored by looking at the correlates of attainment. If a correlate has different values for males and females then it is reasonable to conclude that the correlate causes differences in the test results of males and females. For example, spatial ability is correlated with science test results and males have higher values in that ability, so we can conclude that differences in spatial ability cause differences in science test results, at least to some degree.

There is another way we can search for the correlates for sex differences in attainment. One can find correlations between the differences and characteristics of schooling, students, economic situation, etc. Correlations with sex differences in educational attainment show directly which characteristics may cause the differences in achievement for boys and girls.

Let us use an example. The aim of the following calculations was to find some possible causes of the sex differences in the PISA 2006 results. The data for the calculations were taken mostly from the PISA databases (OECD, 2007). Index of democracy was taken from Kekic (2009), National Intelligence from Lynn and Vanhanen (2006), and Gross National Income per capita from Worldbank database at: <http://siteresources.worldbank.org/DATASTATISTICS/Resources/GNIPC.pdf>. A confirmatory factor analysis was used and the hypothetical model was fitted to the data from 50 PISA 2006 countries (Fig. 2). The model fits the data adequately: $\chi^2(48) = 57.15$ ($p = .17$), RMSEA = .062, CFI = .99.

We can see in the figure that sex differences in PISA test results were larger in countries with higher development measured using the Index of Democracy, National Intelligence and Gross National Income. We can hypothesise that in developed countries everyone has the freedom to develop his/her abilities and that there can be “a restriction of range in scores among poorly developed countries” (anonymous reviewer). The second correlate of sex differences in attainment was motivation. In countries with more motivated students, the sex differences in PISA scores are smaller. High motivation may lead to the achievement of educational standards by most of the students. The third group of correlates was out of school lessons. The more students in a country had four or more out of school lessons in the subject in a week the smaller the differences between boys and girls in PISA scores. It may be that the boys or girls who feel weak in a subject take out-of-school lessons and this diminishes the sex differences in attainment.

The second methodological remark concerns sampling sizes that should be equal for males and females. If, for example, females prevail in the representative sample of college students, then their

average result will be lower than the average for males because a smaller top in normal distribution has a higher average than a larger top. This regularity has been noted in the meta-analysis of gender differences in mathematics performance by Hyde, Fennema, and Lamon (1990, p. 139), who concluded that “Gender differences were smallest and actually favoured females in samples of the general population, grew larger with increasingly selective samples, and were the largest for highly selected samples ...”. Dykiert, Gale, and Deary (2009) have also concluded that “A proportion of the apparent male advantage in general cognitive ability that has been reported by some researchers might be attributable to the combination of greater male variance in general cognitive ability and sample restriction ...”.

There are some other interesting perspectives in the research. Lynn has found that male superiority in science has decreased over time (Table 1). It is logical to conclude from that fact that the Flynn effect in science attainment is different for males and females. Ang et al. (2010) have recently studied the Flynn effect within different subgroups in the US relying on NLSYC data and found no gender effect. Nevertheless, the question of different Flynn effects for males and females deserves to be studied on the basis of other data samples.

Above we have analysed sex differences in complex areas of reading and science. General statements about gender differences in such complex areas may be misleading if we consider some specific aspect of the area. One example of the phenomena is given above regarding science test results (Lynn & Mikk, 2008) and another comes from the studies by Lindberg, Hyde, Petersen, and Linn (2010). The authors found in their meta-analysis that boys were better in short answer problems and girls in multiple choice problems. Earlier Hyde (2005) has raised the Gender Similarities Hypothesis according to which males and females are similar on most psychological features. She has reviewed 46 meta-analyses on psychological gender differences and found that gender effect favours males on some variables and it favours females on other variables. Looking for gender differences in specific areas of educational attainment is an important aspect of future research.

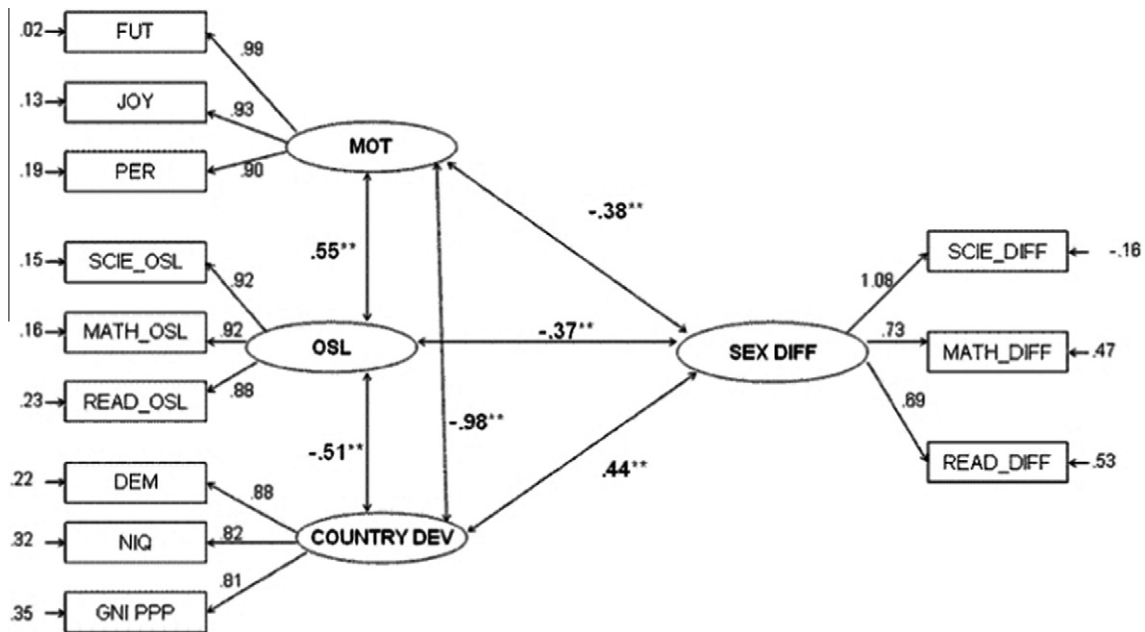


Fig. 2. The model of correlates of sex differences in educational attainment. *Note:* FUT – future oriented motivation to science; JOY – enjoyment of science; PER – personal value of science; SCIE_OSL – Science out of school lessons >4 in a week; MATH_OSL – Maths out of school lessons >4 in a week; READ_OSL – Reading out of school lessons >4 in a week; DEM – Index of democracy; NIQ – National Intelligence; GNI PPP – Gross National Income per capita adjusted by purchasing power parity; SCIE_DIFF – gender differences in student performance on science scores; MATH_DIFF – gender differences in student performance on mathematics scores; READ_DIFF – gender differences in student performance on reading scores; OSL – out of school lessons; COUNTRY DEV – country development; SEX DIFF – sex differences in educational attainment.

Lynn explained the relatively good results of girls in tests of educational attainment in terms of their stronger work ethic and motivation. This was true for the individual level, but this explanation cannot be accepted for the country level. We see here the manifestation of ecological fallacy: the correlation between motivation and educational attainment is about .5 at the individual level, but the correlation between interest in science and international test results is $-.7$ at the country level (Mikk & Täht, 2010). Some correlates of educational achievement at the individual and country level are different (Täht, Must, Peets, & Kattel, submitted for publication), and therefore, multilevel analysis of correlates of sex differences in attainment is an important task for future studies.

6. Limitations

International tests of educational attainment carried out on representative samples in many countries were the sole basis for the analysis of sex differences. This approach was used in the research by Lynn and his co-workers and the approach is used in our survey. However, sex differences in educational attainment should be studied from other aspects as well; for example, the learning strategies used by male and female students.

It became clear from the PISA 2006 Technical Report that in the process of test composition, the test items were analysed for gender-by-item interactions and some items favouring one gender were excluded. It was impossible to calculate how much this exclusion diminished gender effect in PISA test results. There were excluded items favouring both boys and girls however, gender difference in test results exist, especially in reading. In spite of the pursuit to compose items not favouring boys or girls there exist gender differences in the summary results of the tests.

7. Concluding remarks

Lynn and Meisenberg (2010) have recently shown that the correlation between educational attainment and National IQ is .92 at the country level. Consequently, the relationships with National IQ can be transferred to educational attainment and vice versa. However, at the individual level, the correlation between IQ and educational achievement is about .5 and therefore many other factors may influence achievement and differences in achievement between males and females.

The analysis of international test results by Lynn and colleagues revealed that males outperformed females in science by $0.15d$ and females were better readers by $0.23d$ at the age of 10 years and by $0.42d$ at the age of 15 years. Lynn's recent work has shown that boys' advantage in science tests is diminishing over time. The variance in males' test results is about 12% larger than the variance in females' test results. Causes of the differences can be seen in abilities, motivation and activities.

The difference between male and female average test achievement results may be up to one third of a standard deviation. This means that the distributions mostly overlap. Girls are better at reading than boys, but there are many males who read better than most of the females. Males achieve higher results in maths tests on average, but many females do maths tests better than most of males.

Lynn has considerably advanced studies on sex differences. He has asked some simple but fundamental questions and given convincing answers relying on the research results of many studies. Lynn has created a lively research community which discusses problems concerning many people.

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